HIGH ALTITUDE BALLOON-TOP COLLECTIONS OF COSMIC DUST

by

C. L. Hemenway, D. S. Hallgren and R. E. Coon

Dudley Observatory, Albany, N. Y., and
The State University of New York at Albany

ABSTRACT

Fluxes of cosmic dust particles incident on the earth's atmosphere have been measured at high altitude with a balloon-top collection technique. Particle flux enhancements of 5 to 100 times have been observed at times of meteor shower activity. Typical particles and comments concerning their chemical analyses are presented. Evidence concerning the absence of crystal structure in cosmic dust particles is presented. Fluxes obtained by this technique are compared with those from rocket collection and satellite microphone techniques.

N 67 11696
(ACCESSION NUMBER)
(THRU)
12
(PAGES)
1
(CODE)
CR 79623
(NASA CR OR TMX OR AD NUMBER)
13
(CATEGORY)
FACILITY FORM 602

GPO PRICE $

CFSTI PRICE(S) $

Hard copy (HC) 1.00

Microfiche (MF) .50

ff 653 July 65

This paper briefly describes a balloon-top technique for collecting cosmic dust, shows typical particles obtained with this technique, presents evidence concerning the absence of crystal structure in cosmic dust particles and compares the fluxes of particles measured by the balloon-top and rocket techniques with those of satellite microphone techniques.

The balloon-top collector (Sesame) used for these collections is shown in Figure 1. It consists of a rugged anodized aluminum box approximately 7"x7"x3" in size and weighing about 12 lbs. Inside the box there are two cassettes, each containing eight 1"x2" slides which face upward during exposure and four control slides (not visible) which face downward, but do not touch the bottom of the cassettes. One cassette is mounted in the cover of the box and the other in the body of the box. In Figure 1 the box is shown not quite fully open. A silicone rubber gasket is in the upper rim of the box and mates with the cover to seal the box while the collector is being launched and recovered. An air-bleed containing five millipore filters in series allows air pressure within the collector to be kept equal to the outside air pressure at all times. The collection device is unlatched at collection altitude by two parallel sealed squibs (bellows actuators) and opened by an electric motor. Control and power wires are encased in a special sleeve to provide electrical connections between the bottom and top payloads. The telemetry receiver and transmitter, ballast and battery power are located in the bottom payload. Opening and closing of the collector is accomplished by ground command while the balloon is at float altitude. Opening, closing, fully-open and completely-closed conditions of the Sesame collector are confirmed by a telemetry system. The collector is locked at exposure altitudes with three enclosed steel bolts driven by sealed squibs (bellow actuators) into tongues attached on three sides of the cover.

Figure 2 shows the Sesame collector mounted on the framework which holds it above the top surface of the balloon during flight. The recovery beacon and parachute housing are also shown. Figure 3 shows the Sesame collector on top of the bubble of the balloon just prior to launch. The bottom payload is not visible.

Most of the balloons have been launched at the National Center for Atmospheric Research (NCAR) Scientific Balloon Flight Station at Palestine, Texas, U.S.A. Thus far eleven successful flights have been made although data has been analyzed sufficiently for publication from only six of these flights. One Sesame collector has been flown successfully eight times. Exposures range from 5 to 35 hours and are generally limited by the time it takes the balloon to drift to the Rocky Mountains or to the Atlantic Ocean. Most flight exposures were made at altitudes between 110,000 and 115,000 feet.

The collector casettes are loaded with collection slides in a "dust-free" hood in a clean room environment. Two types of collection surfaces have been used: 200 Ångstrom thick nitrocellouse coated with an evaporated coating of aluminum approximately 100 Ångstrom thick on a 200 mesh copper screen and highly polished aluminum slides coated with a thin film of mineral oil.

Three of the balloon collections were made at times free from meteor shower activity and the remaining eight collections were made during meteor shower activity. Table I shows estimates of the time in days required for spherical particles of different diameters and density 3 gm/cm^3 to fall from altitudes where their terminal velocities are 11 kilometers per second to the indicated altitude. The collections at times

Altitude	Diameter in Microns			
in Feet	5	10	20	40
115,000	5.0	2.2	1.1	0.48
105,000	7.2	3.4	1.1	0.54
95,000	10.0	3.8	1.4	0.58

Table I

of meteor shower activity were generally made several days after the peak of the shower. Table II shows the fluxes of particles larger than 5, 10, 20, 40 and 80 microns in average diameter collected on the indicated flight dates.

Date of Flight	Flux (#/meter^2-sec.x10^{-2}) $>5\mu$	$>10\mu$	$>20\mu$	$>40\mu$	$>80\mu$
Nov. 8, 1963	1.9	1.6	0.9	---	---
Dec. 15, 1963	16	8.7	3.8	2.1	.5
June 10, 1964	38	16	1.6	---	---
Aug. 12, 1964	160	88	33	10	2
Nov. 9, 1964	2.2	1.3	---	---	---
Dec. 14, 1964	21	15	12	4.2	---

Table II

No particles smaller than 5 microns in average diameter were counted although some were observed. It will be noticed that most of the particles collected by the Sesame technique were greater than 10 microns in diameter. The fluxes of particles on successive years around Nov. 9-10 appear to be consistent although few particles larger than 20 microns were found. At times of meteor shower activity the flux appears to increase by factors ranging from 5 to 100 times and significant numbers of large particles (greater than 20 microns) are found.

Figure 4 shows a large irregular particle collected at the time of the Geminid shower. Figure 5 shows another irregular Geminid particle. Figure 6 shows a large magnetic irregular particle collected at the time of the Perseid shower. Almost all of the particles collected have been irregular in shape. Most of the particles have been dark in color, brown and black being common colors.

Thus far 14 particles each larger than 20 microns in average diameter have been analyzed by a sensitive x-ray technique to search for evidence of crystal structure.[1] Ten of the particles were collected at the time of the Geminid shower, three during the Perseid shower and one during the Zeta Perseid-Arietid shower. Only one of these particles, an enormous magnetic Geminid particle (180μ x 72μ) showed a diffraction pattern. This pattern has not been identified and we are certain that the particle is not a contaminent. Our x-ray techniques have been tested by making test measurements on three artifical crystalline particles, each smaller than 20 microns in diameter. All three test particles gave clearly detectable diffraction patterns. Thus it appears that the large cosmic dust particles collected at times of meteor shower activity are amorphous. Electron diffraction measurements of the Venus Flytrap particles have also indicated that few large particles are crystalline[1,2] although electron diffraction techniques are limited to examining the surface layers of particles. At present it is not known if their lack of crystal structure is related to the method of formation of these particles or the result of cosmic ray proton bombardment in space. In any case, these surprisingly-large particles have not been annealed by heating during entry into the earth's atmosphere and it appears necessary to consider the role of ablation and sputtering during their entry.

Electron-beam-probe measurements have been made of some of the particles. Some particles have shown the presence of iron and have been found to be magnetic. A few particles have shown no detectable elements heavier than sodium and may possibly be organic in nature. Compositions vary widely from particle to particle as was the case with the analysis of the Venus Flytrap particles.(1) Some particles are easily evaporated and show composition changes during electron-beam-probe anaysis. At present our electron-beam-probe data do not warrant more than these few qualitative observations.

Figure 7 shows a comparison of the flux data obtained from the first six Sesame balloon collections with the Venus Flytrap and Noctilucent Cloud control rocket collections(3) and the satellite microphone data as averaged by Mc Cracken and Dubin.(4) Although the data obtained by these three different techniques each show fluctuations of one or two orders of magnitude, they appear to be in fair agreement. The shallow slope of the Sesame data at times of shower activity in the small size range from 5 to 10 microns may be related to the longer time required for the particles to fall to their collection altitudes. The flux data appears to be inconsistent with the Pegasus data[5] and appear to be larger by 4 or 5 orders of magnitude than predicted influx rates from Zodical light considerations.[6,7] It should be noted that the balloon-top techniques are direct measurements of flux whereas the satellite and rocket techniques require calibration and interpretation. These results imply that the dust particles captured by the earth cannot remain long in satellite orbits and that the earth's capture cross-section for dust particles is significantly greater than the earth's geometric cross-section.

This work was carried out under NASA Grant NsG-155-61. We also express our appreciation to H. Chessin, A. Laudate, J. Dugan, B. Marsh and R. Spenser of Dudley Observatory and the personnel of the NCAR Balloon Flight Center at Palestine, Texas, U.S.A.

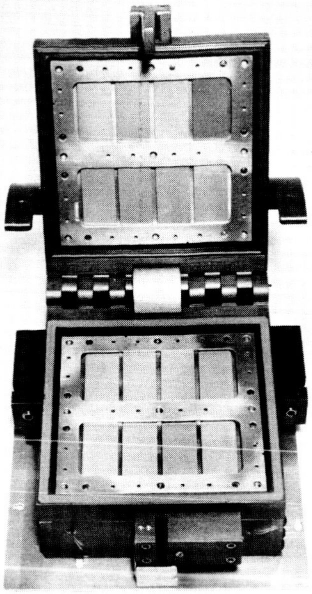


Figure 1. Sesame balloon top micrometeorite collector.

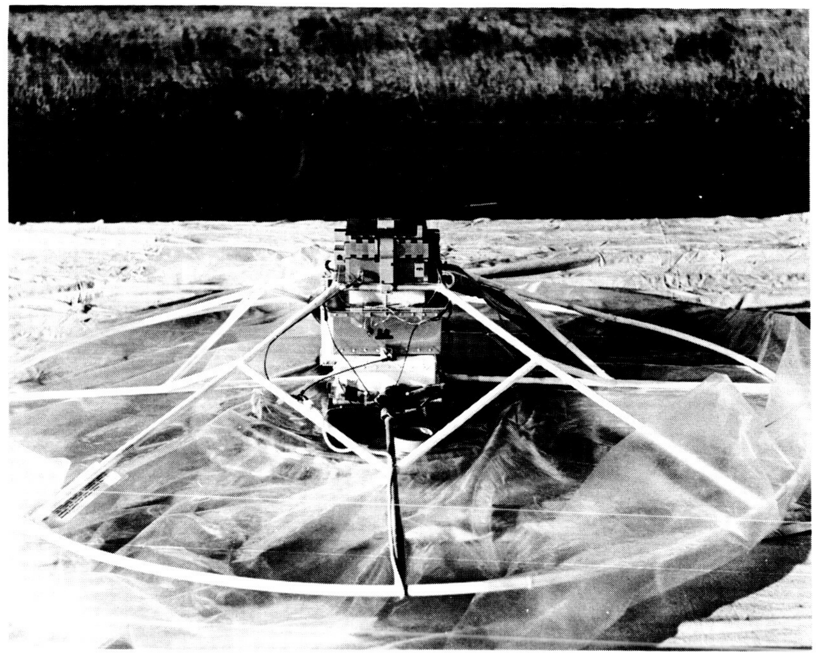


Figure 2. Collector mounted on frame.

Figure 3. Balloon just prior to launch.

Dudley Observatory
Albany, New York, U.S.A.
May, 1966

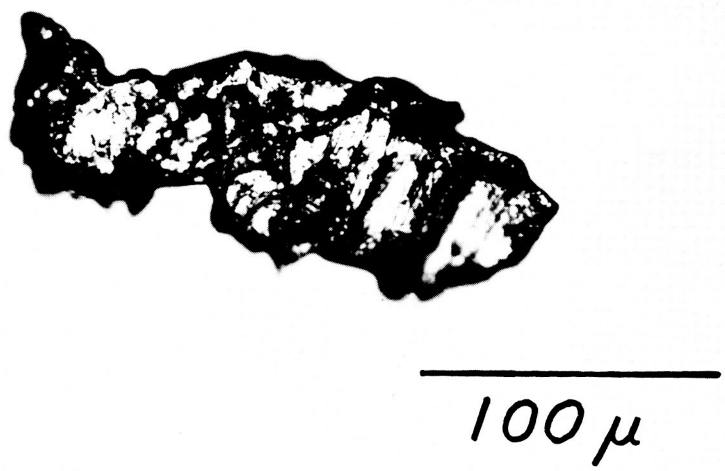


Figure 4. Particle from Geminid meteor shower.

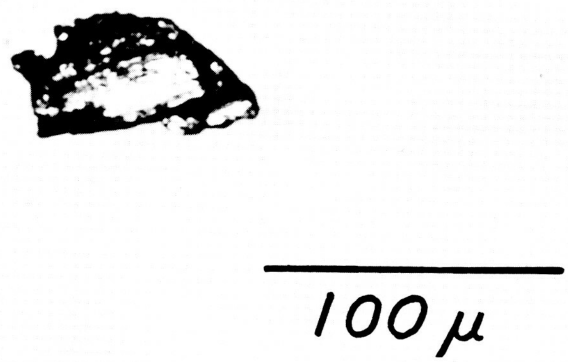


Figure 5. Particle from Geminid meteor showers.

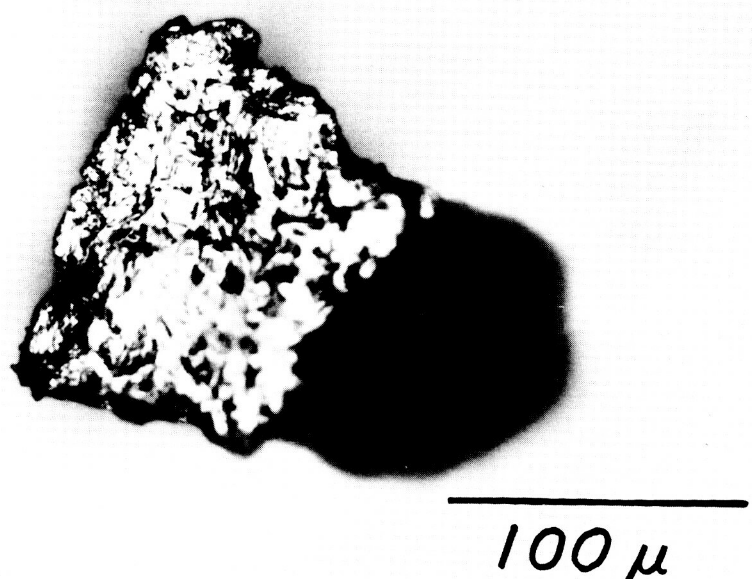
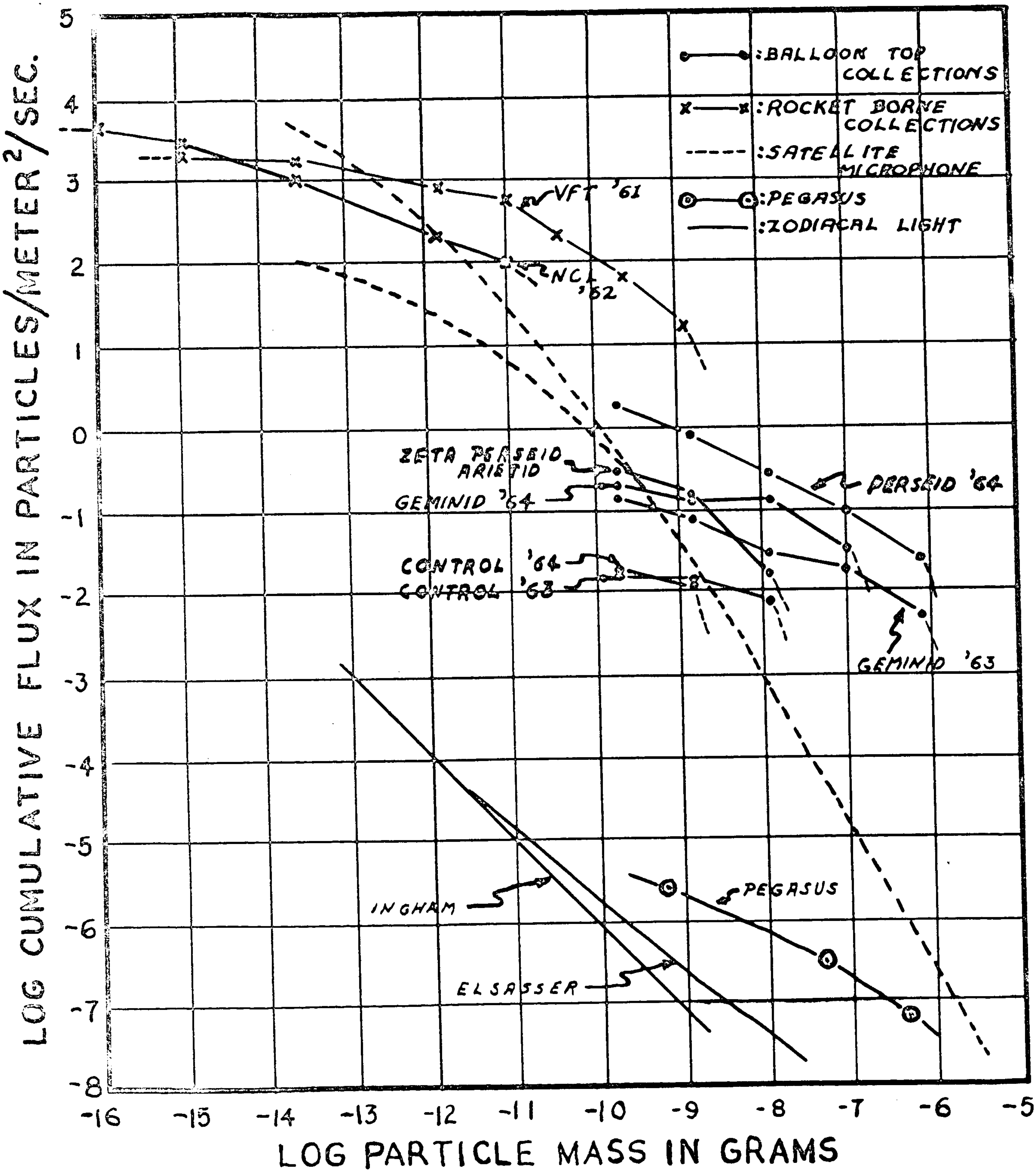


Figure 6. Particle from Perseid meteor shower.

Dudley Observatory
Albany, New York, U.S.A.
May, 1966



:BALLOON TOP COLLECTIONS
:ROCKET BORNE COLLECTIONS
:SATELLITE MICROPHONE
:PEGASUS
:ZODIACAL LIGHT
VFT '61
NCL '62
ZETA PERSEID
ARIETID
GEMINID '64
CONTROL '64
CONTROL '63
PERSEID '64
GEMINID '63
INGHAM
PEGASUS
ELSASSER
LOG CUMULATIVE FLUX IN PARTICLES/METER²/SEC.
LOG PARTICLE MASS IN GRAMS

FIG. 7

References

1. C. Hemenway and R. Soberman, Studies of Mircometeorites Obtained from a Recoverable Sounding Rocket, A. J., 67, (5), p. 256-266, June 1962.

2. N. Greenman, Heat Annealing Experiments Performed on "Venus Flytrap" Particles, Ann. N. Y. Acad. Science, 119, Art. 1, p. 298-317, Nov. 1964.

3. R. Soberman and C. Hemenway, Meteoric Dust in the Upper Atmosphere, J. G. R., 70, (19), p. 4943-4949, Oct. 1965.

4. C. Mc Cracken and M. Dubin, NASA Tech. Note D-2100, Dec. 1963.

5. P. Burbank, Private Communication, May 1966 and NASA Technical Note TMX 1192.

6. H. Elsasser, Die raumliche Verteilung der Zodiakallicht-materie, Zeit. f. Astrophys., 33, (4), p. 274-285, 1954.

7. M. Ingham, Observations of the Zodiacal Light from a High Altitude Station IV. The Nature and Distribution of the Interplanetary Dust, M. N. Roy. Ast. Soc., 122, (2), p. 157-175, 1961.